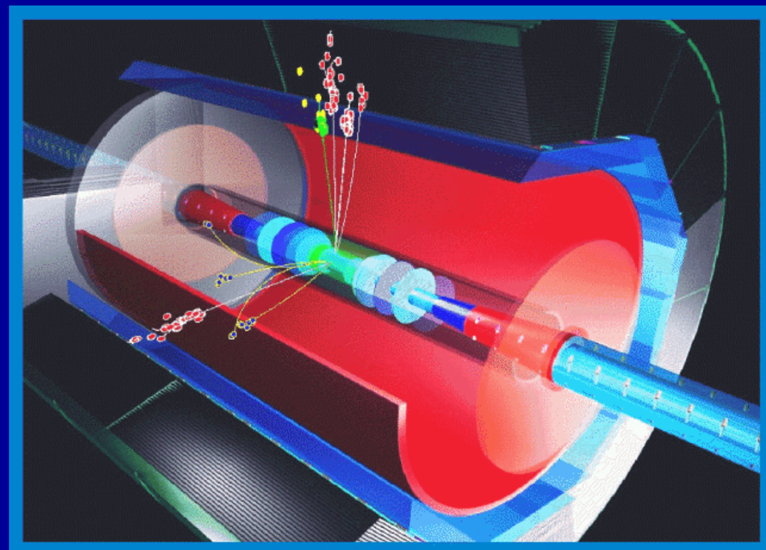
TPC LC Meeting October 18, 2003

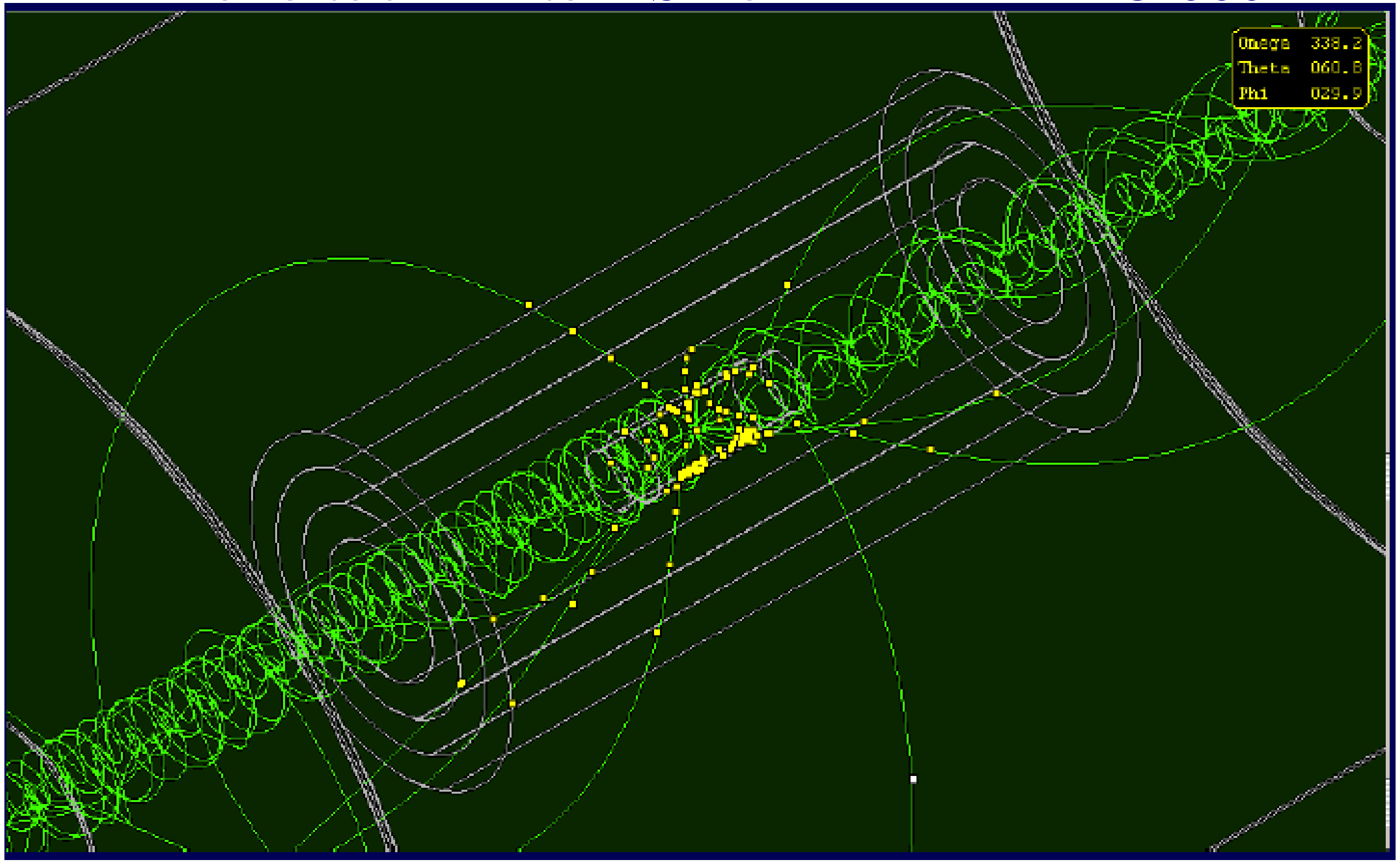
Physics Requirements for the LC Main Tracker



Marco Battaglia
UC Berkeley and CERN, Geneva

Backgrounds in Main Tracker

Background from Single BX at NLC-500

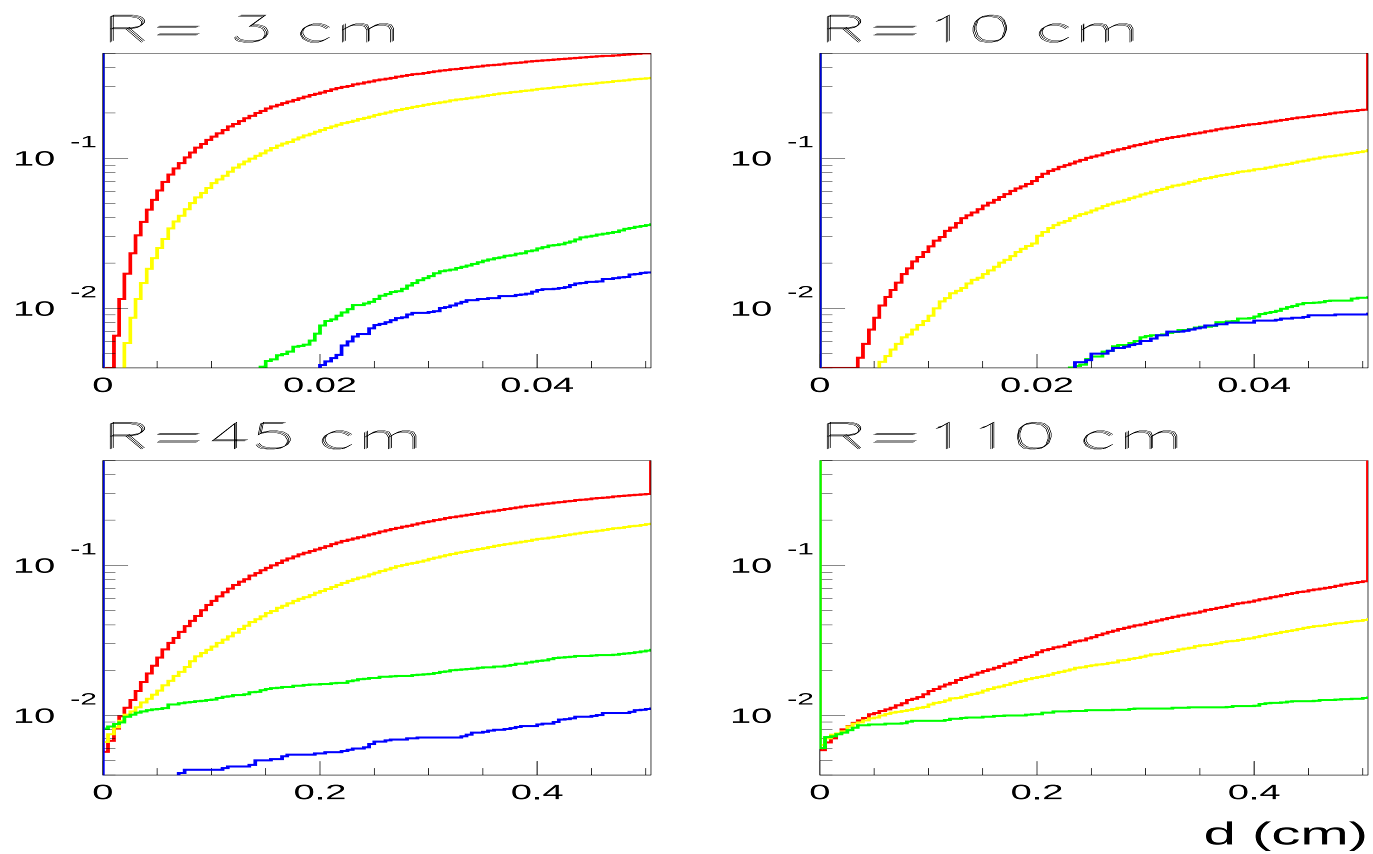


✧ Managing PatRec in presence of accelerator induced background, also for low p tracks, may be a decisive feature for Main Tracker technology choice.

Tracker Occupancy in Multi-Jet Evts

Distance from closest track in

$e^+e^- \to W^+W^-$ at $\boxed{\sqrt{s} = 200, 500, 3000, 5000 \text{ GeV}}$

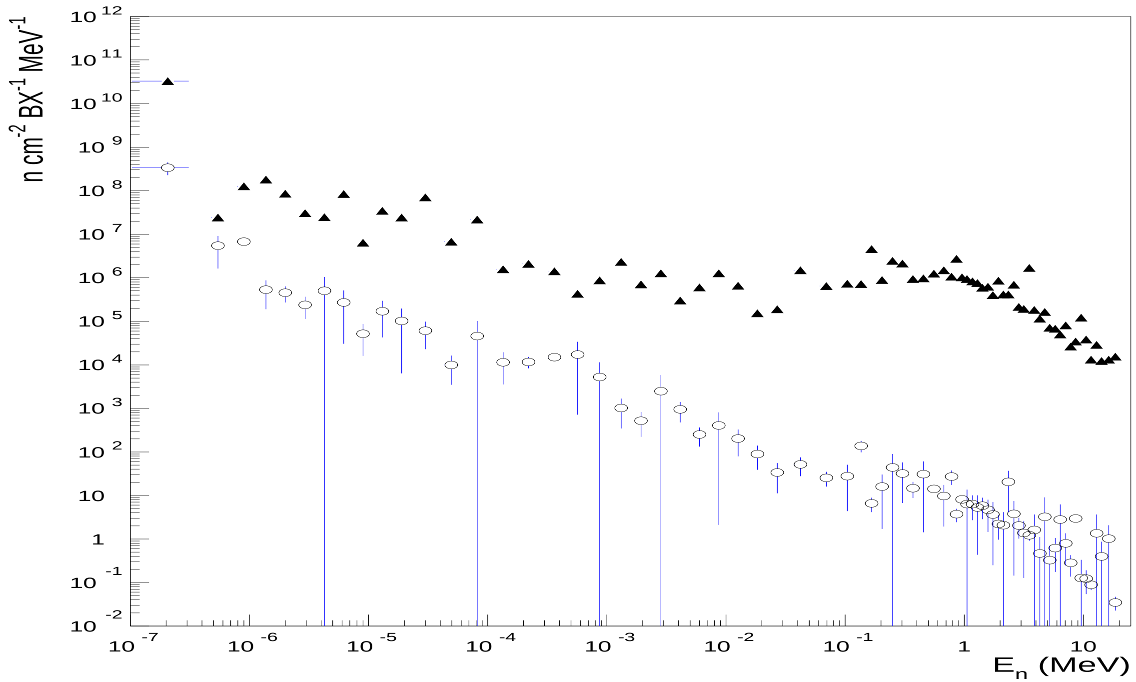


Neutron Background

✦ Neutrons produced in giant dipole resonance excitation, pseudo-deuteron mechanism and photo-pion reaction by spent beams, beamstrahlung (300 kW/BX), pair (260 GeV/BX) and radiative Bhabha (2100 GeV/BX) fluxes;

✦ Main source of neutrons reaching the TPC volume is pair dump and the estimated flux is $\simeq 15000\ n$ BX^{-1} for TESLA at 500 GeV.

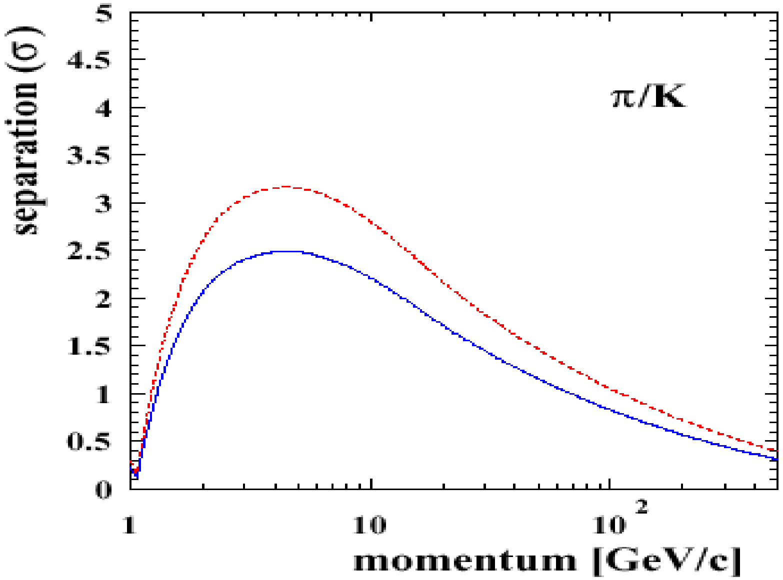
Energy Spectrum from FLUKA Simulation



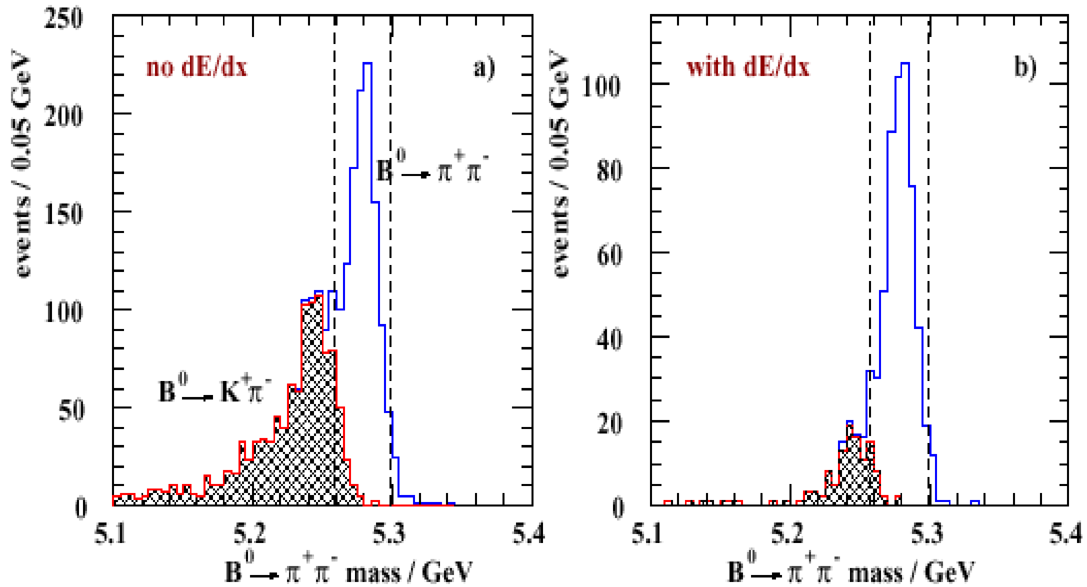
Hadron Identification

✧ Although no golden channel is known, which dictates good hadron id at TeV-class LC, TPC dE/dx likely to provide only handle for hadron tags and a key input for electron id at low momenta;

π/K Discrimination vs. p with TESLA TPC



$B \to \pi\pi / B \to K\pi$ Separation before/after dE/dx K id



✧ Important to review the relevance of K_s^0 and Λ^0 to energy flow and tagging;

✧ Kink detection may represent a crucial issue in GMSB models with decays such as $\tilde{\tau} \to \tau\tilde{G}$ and $\tilde{\mu} \to \mu\tilde{G}$ which can be characterised by decay length $c\tau$ of $\mathcal{O}(\mu m)$ - $\mathcal{O}(m)$;

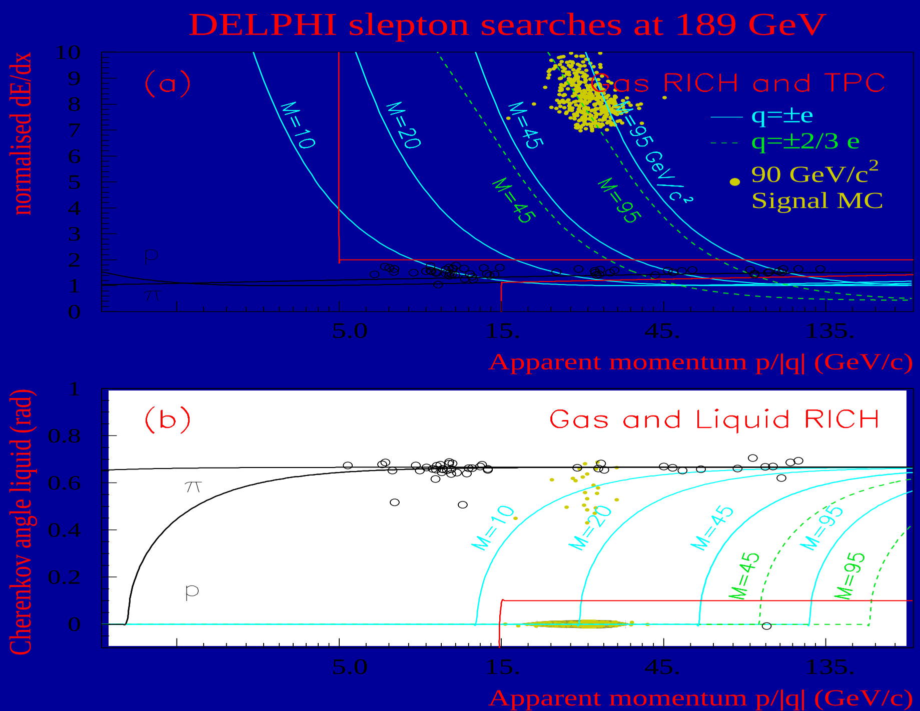
Heavy Particles in GMSB

✧ In Gauge-mediated Supersymmetry Breaking Models (GMSB), gravitino is LSP and due to its weak coupling, NLSP (neutralino or stau) is long-lived;

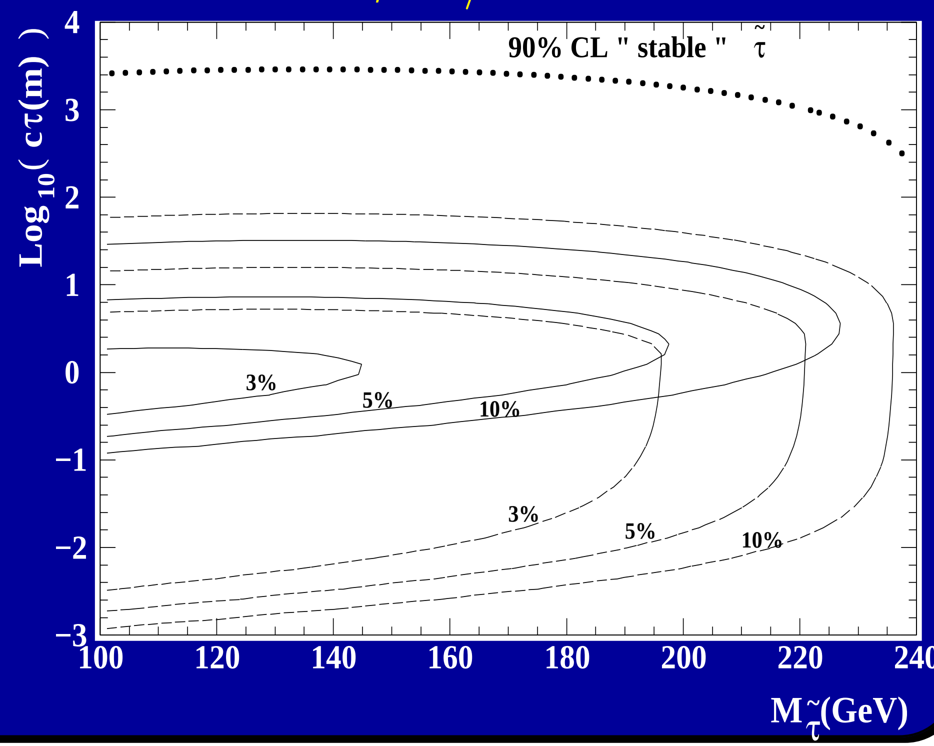
✧ $\tilde{\tau}$ NLSP scenario with $\tilde{\tau} \rightarrow \tilde{G}\tau$ can be investigated in $e^+e^- \rightarrow \tilde{\tau}\tilde{\tau}$;

✧ signature is heavy long-lived charged particle traversing the whole detector,
$\rightarrow$ need to reject $\mu^+\mu^-$ background by particle id.;

Analysis pioneered at LEP using dE/dx and RICH in DELPHI:

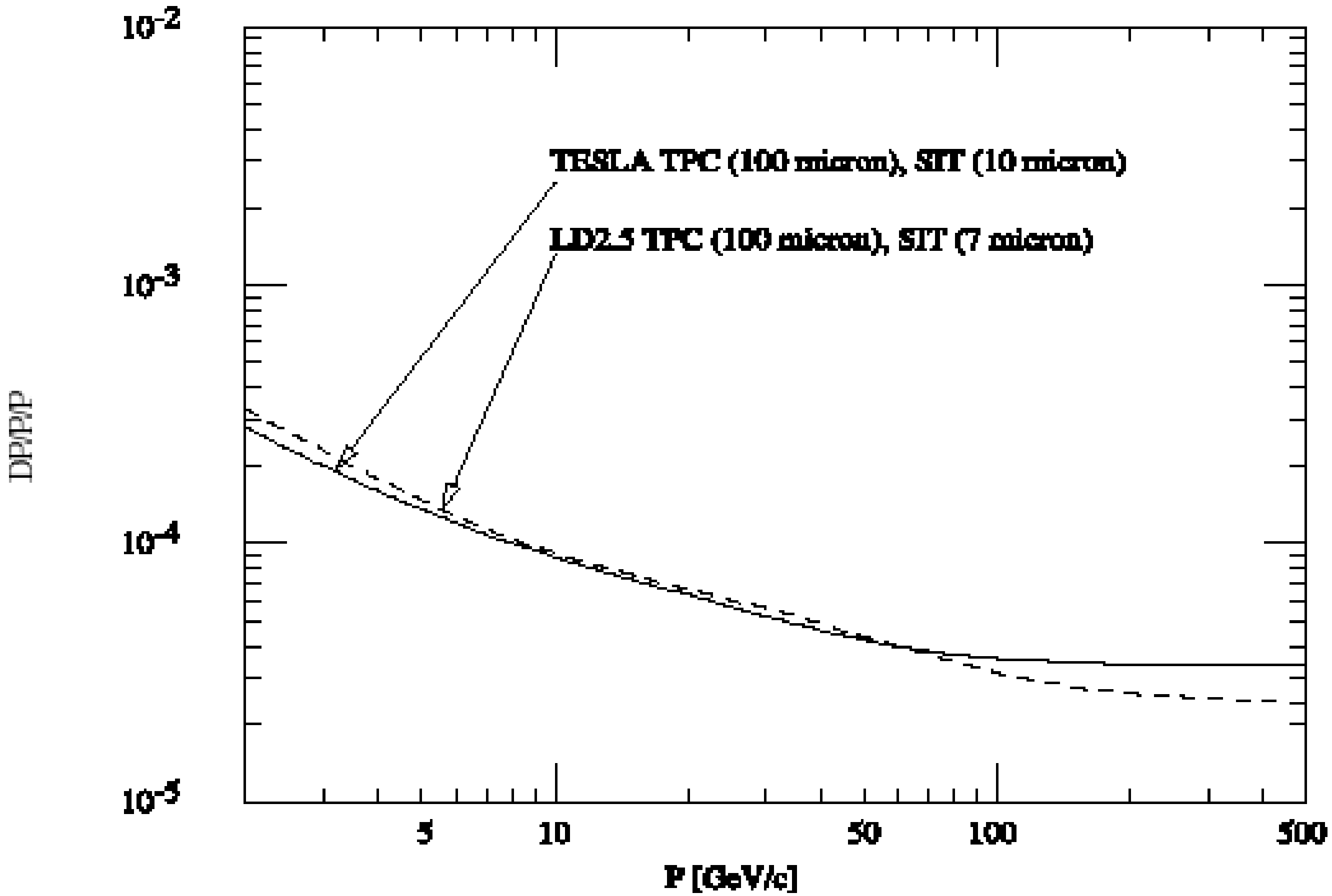


LC able to measure $c\tau$ important to estimate SUSY breaking scale using kinematics, dE/dx and TOF:



Momentum Resolution

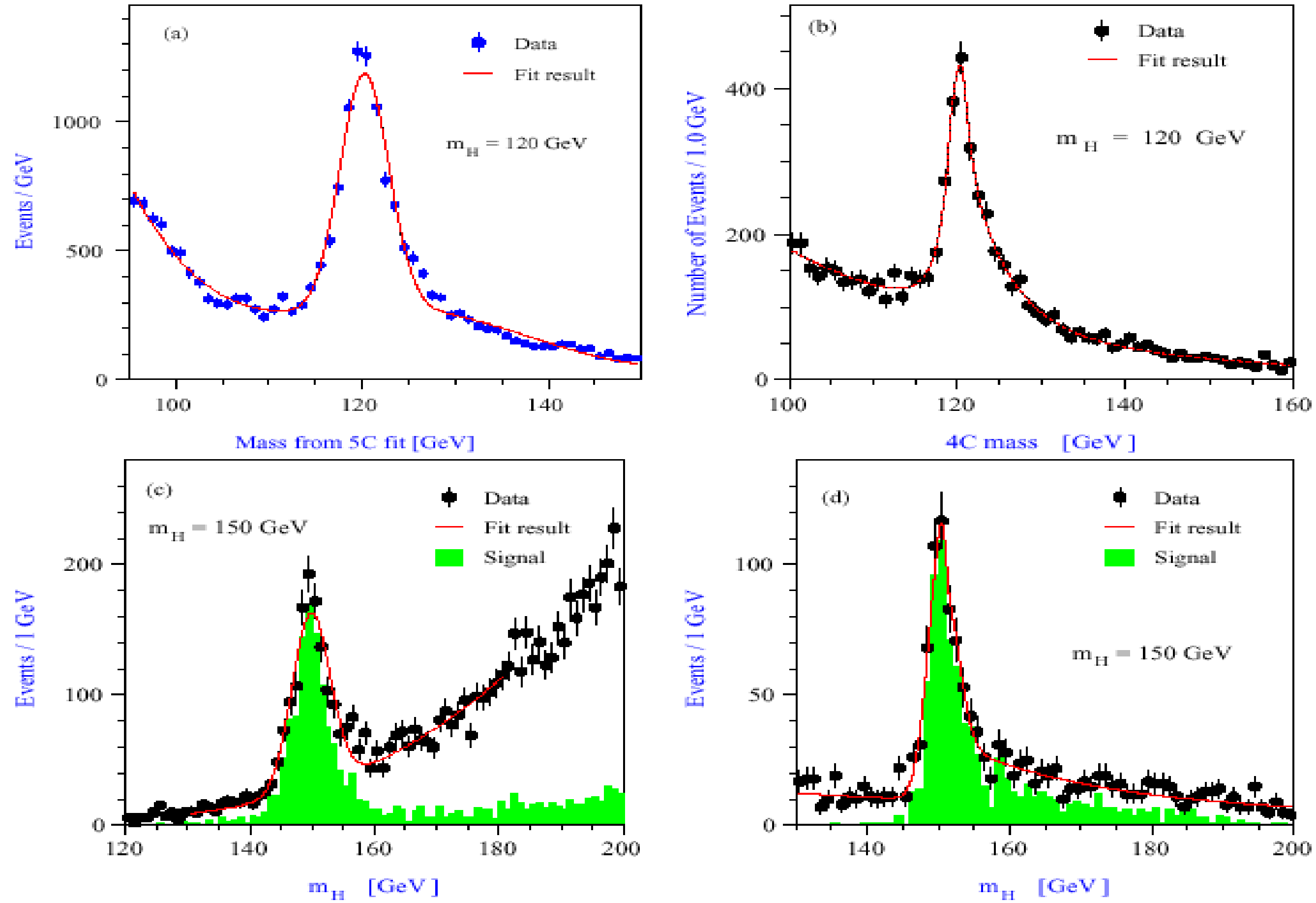
Comparison of American and TESLA TPC designs



Momentum resolution (dp/p^2) vs. momentum (GeV)

Higgs Mass Determination

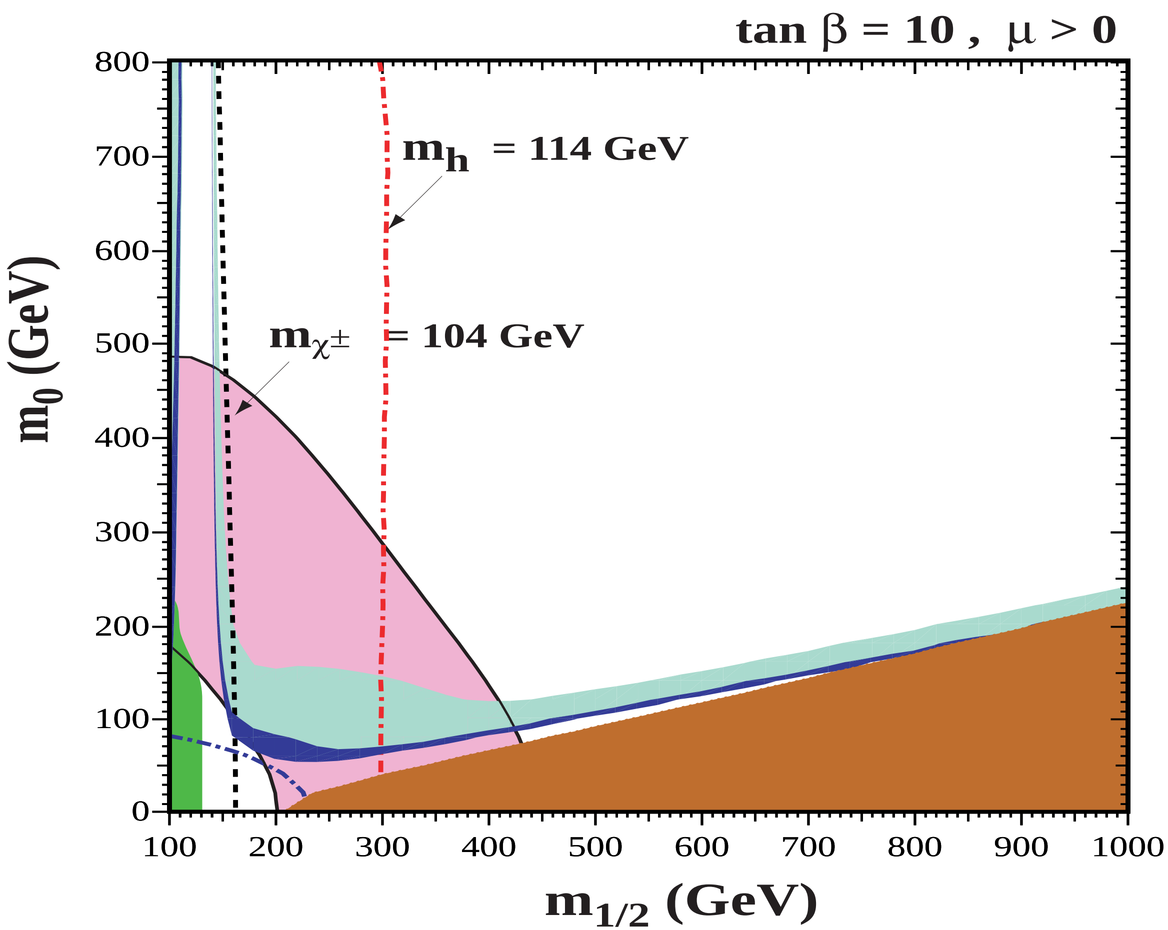
✧ Require resolution contribution from $\delta p/p^2$ to $M_{\ell\ell}^{recoil}$ $<<$ compared to that from ISR and beamstrahlung and beam energy spread (0.1% at TESLA);



✧ Momentum resolution is a key issue not only for the benchmark $\ell\ell$ recoil mass but also for di-jet invariant mass, providing ultimate mass resolution at LC.

SUSY along WMAP lines

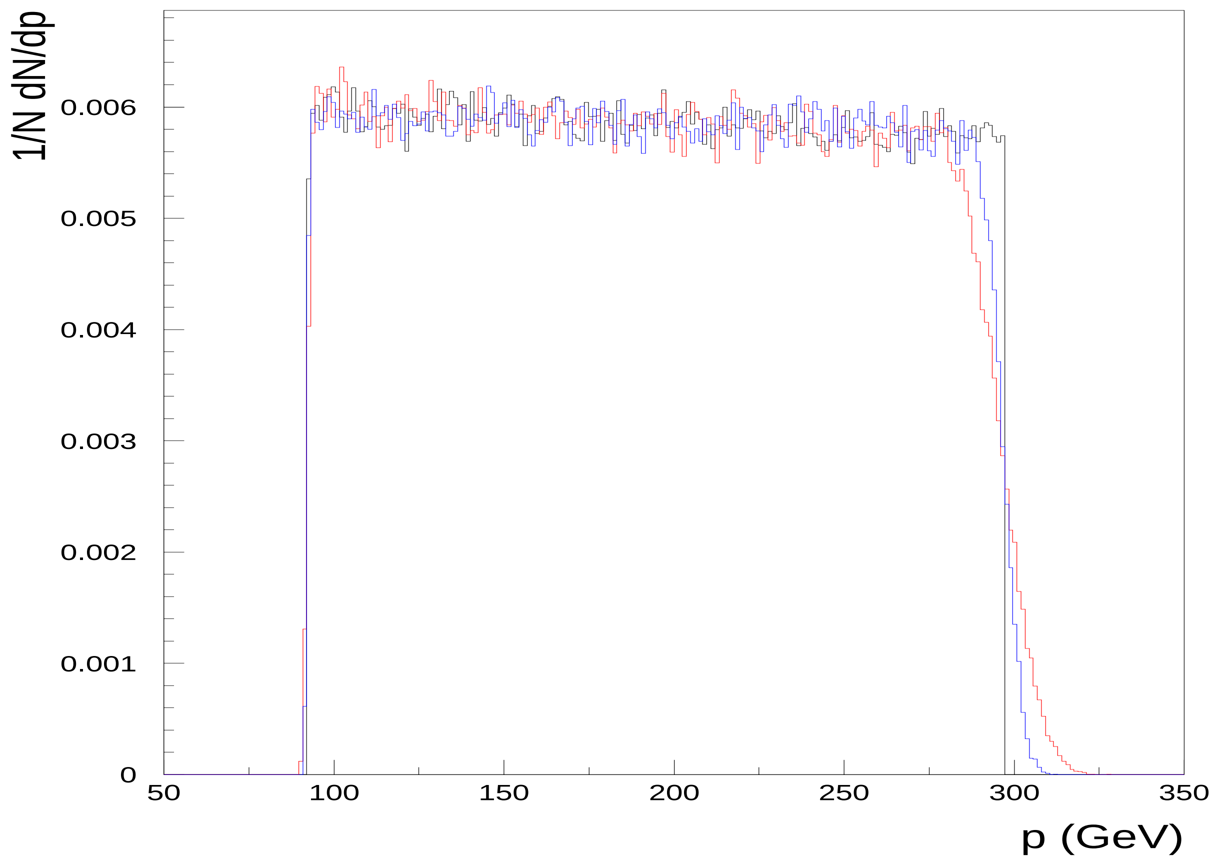
✧ Recent WMAP result on CDM density significantly bounds parameter space of constrained MSSM models such as the cMSSM and suggests scenarios with nearly degenerate slepton - χ^0 masses which provide cosmologically interesting DM densities:



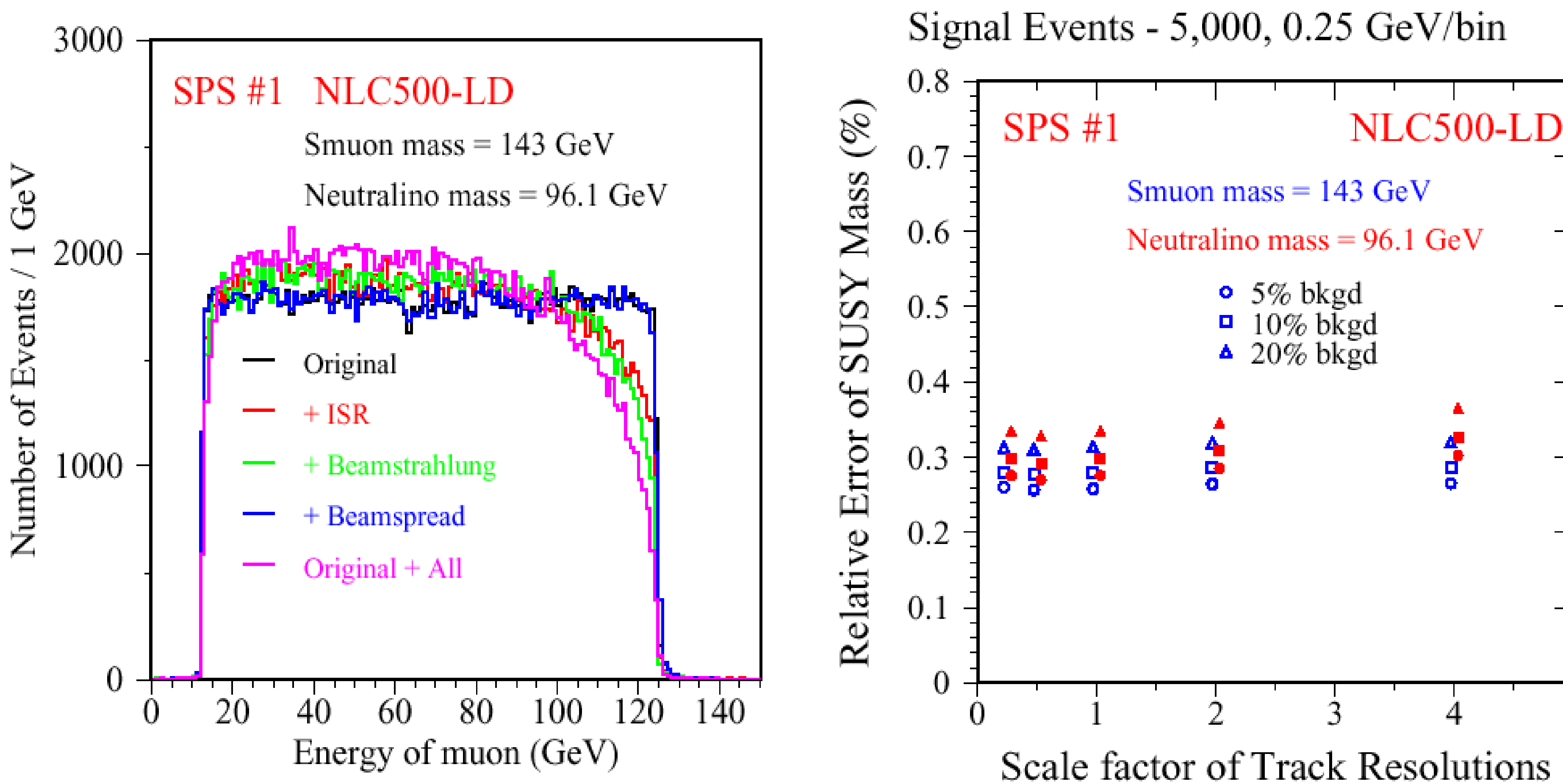
Slepton Mass Determination

MOMENTUM DISTRIBUTION FROM $\tilde{\ell} \to \chi\ell$ FOR POST-WMAP POINT A$'$

with $\delta p/p^2 =$ 0, 5×10^{-5}, 1×10^{-4}



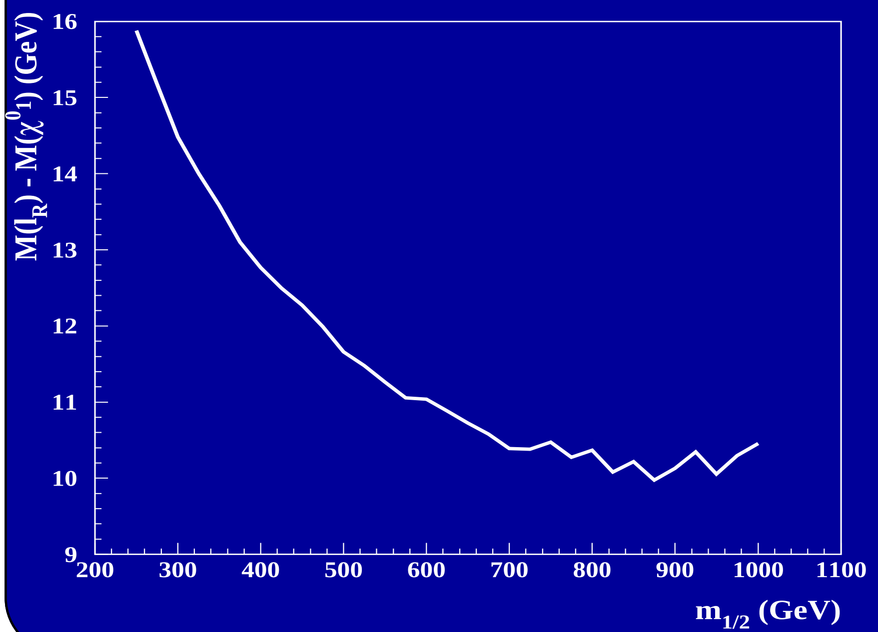
✧ However, slepton mass reconstruction is only marginally affected by tracking resolution, while it significantly depend on the beamstrahlung, both at TeV-class and multi-TeV LC;



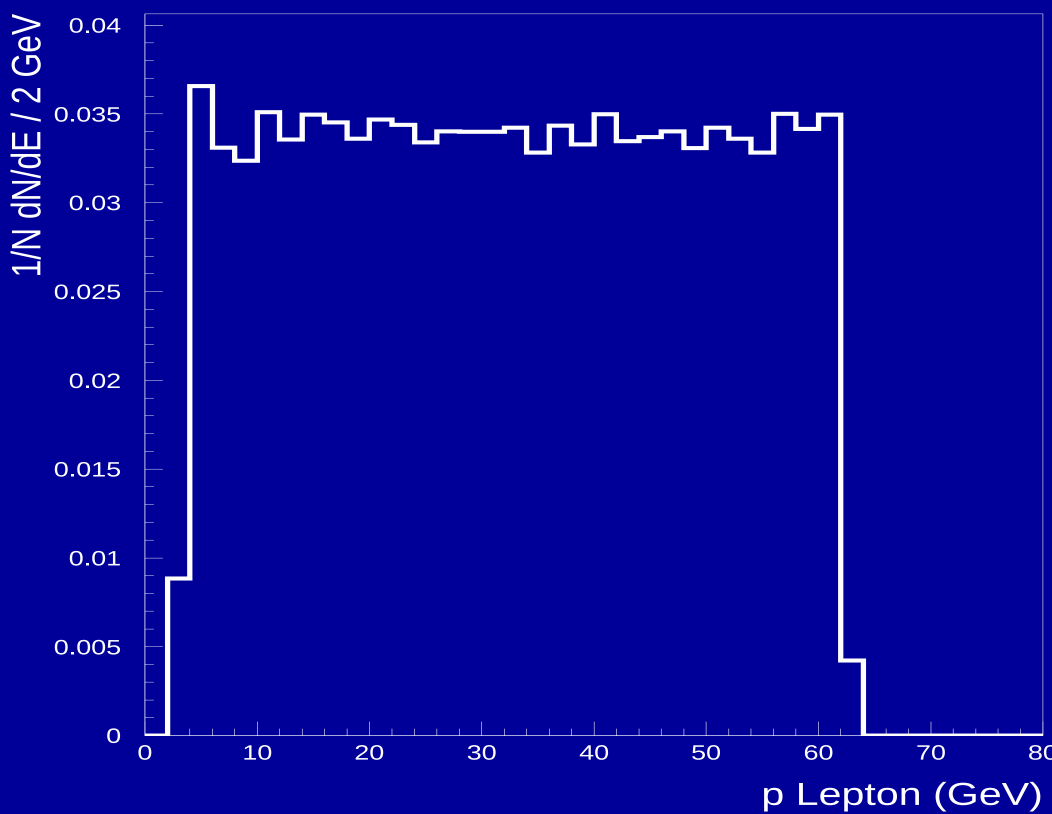
Masses from Momentum Endpoints

✧ e^+e^- collider expected to complement LHC in study of sleptons and gaugino, in particular determining LSP properties;

✧ In cMSSM, recent WMAP CDM result tightly constrains parameters and suggests narrow strip in m_0-$m_{1/2}$ plane extending to small slepton-LSP mass differences, corresponding to soft particle spectra;



$$e^+e^- \to \tilde{\ell}_R\tilde{\ell}_R \to \ell^+\ell^-\chi^0_1\chi^0_1$$



$$E_\ell^{mx/mn} = \frac{1}{2}M_{\tilde{\ell}}\left(1 - \frac{M^2_{\tilde{\chi}^0_1}}{M^2_{\tilde{\ell}}}\right) \times (1 \pm \sqrt{1 - \frac{M^2_\ell}{E^2_{beam}}})$$

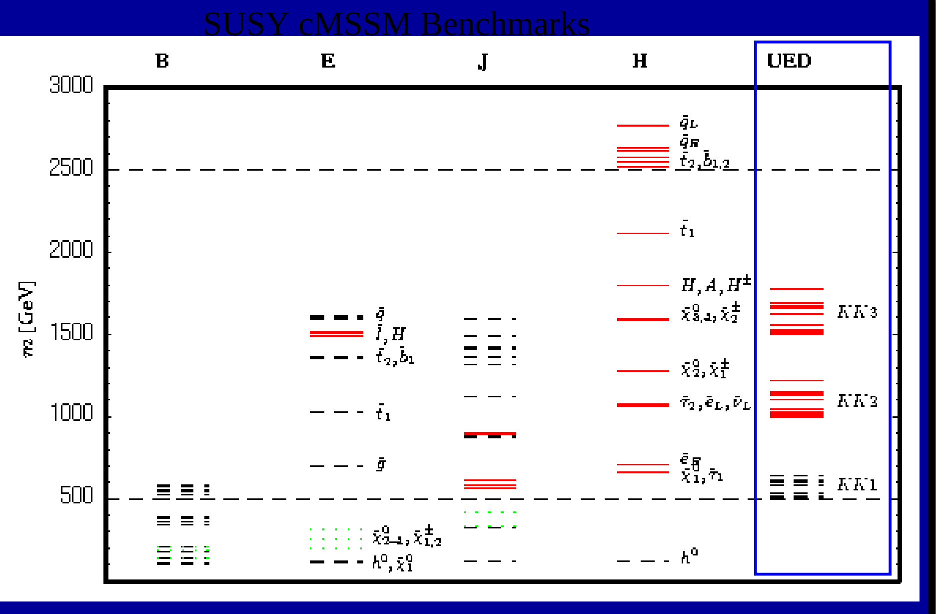
Universal Extra Dimensions

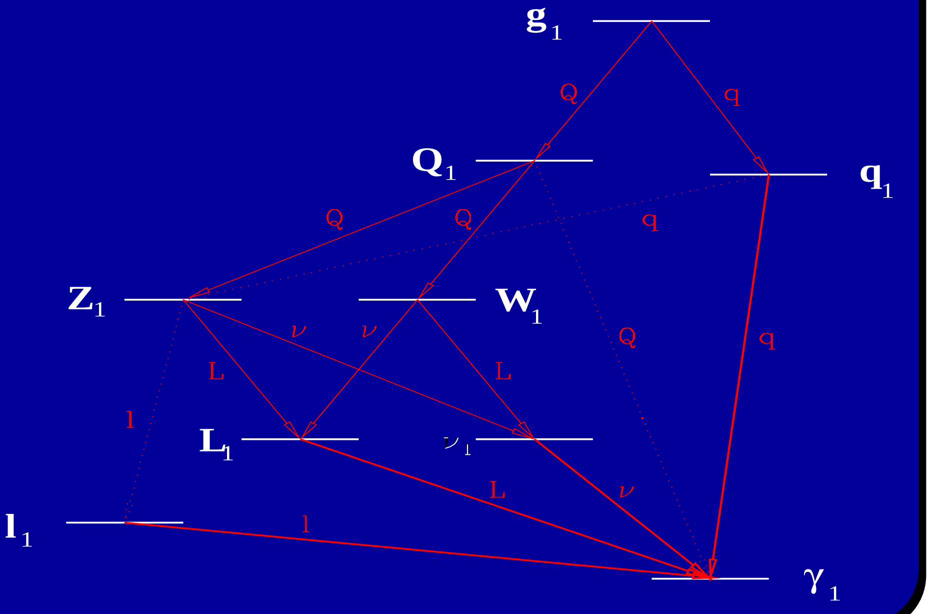
✦ Extra dimensions are being actively explored as alternative schemes to solve hierarchy problem, with most of their realisations expected to give spectacular signals at LHC and LC;

✦ Universal Extra dimension models have all SM particles propagating in one or more compact extra dimensions; Kaluza Klein partners of SM particles have masses $\simeq nR^{-1}$ and identical spin and couplings to SM particles;

✦ Same KK-level degeneracy broken by radiative corrections, KK-parity conservation guarantees lightest KK state stable (generally $\gamma^{(1)}$, $\nu^{(1)}$);

✦ Typical signatures $Jets + E^{miss}$, $\ell + E^{miss}$ and spectra mimic SUSY raising the question of model differentiation at LHC, while they can be disentangled at LC.





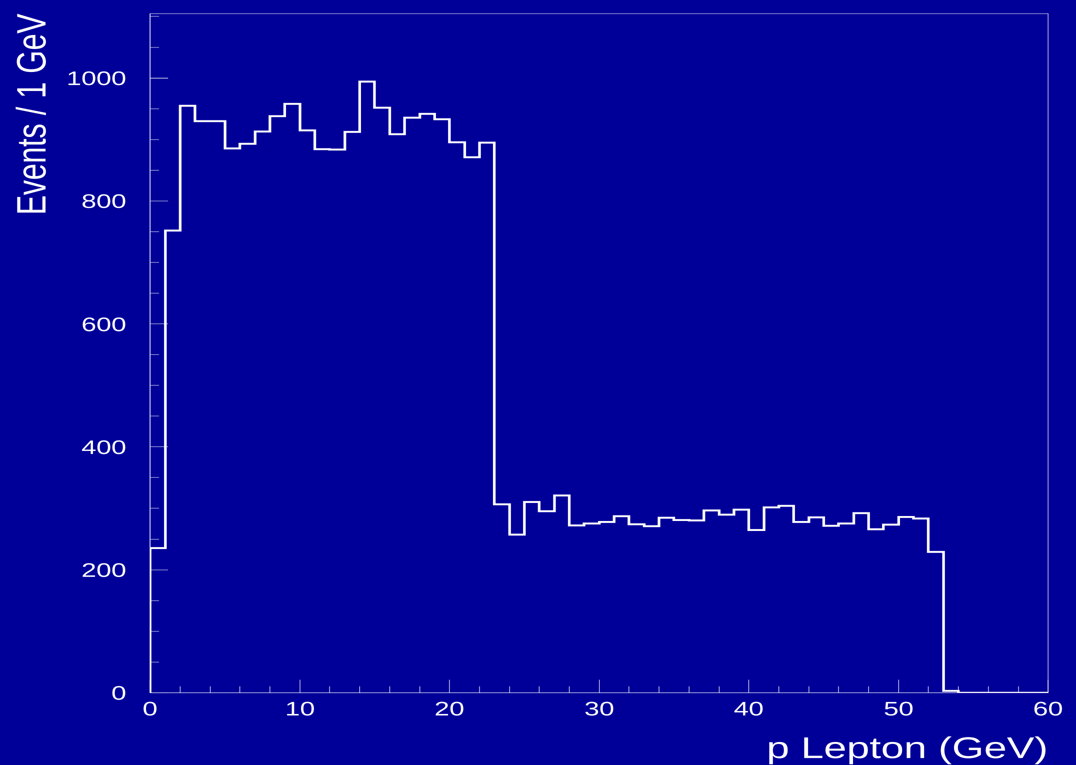
✧ UED offers viable CDM candidate as lightest stable KK particle, if this is responsible for WMAP Ωh^2, then expect UED signals to be first observed at LHC ;

✧ At LC processes $e^+e^- \to e^{(1)}e^{(1)} \to e^+e^-\gamma^{(1)}\gamma^{(1)}$ and $e^+e^- \to \mu^{(1)}\mu^{(1)} \to \mu^+\mu^-\gamma^{(1)}\gamma^{(1)}$ offer clean detection of the $2\ell + E_{miss}$ states;

✧ Can determine spin of KK excitation and measure $\ell^{(1)}$ and $\gamma^{(1)}$ masses similarly to slepton analysis in SUSY;

✧ Need to measure all lepton momentum endpoints to solve for $\ell^{(1)}$ and $\gamma^{(1)}$ masses

Lepton Momentum Distribution in UED $e^{(1)}$ and $\mu^{(1)}$ Production



✧ Sensitivity to nearly degenerate $\ell^{(1)}$ and $\gamma^{(1)}$ states requires to extend efficiency of lepton tagging to $\mathcal{O}(1\text{ GeV})$ momenta.